Optical study of radiation damage in epitaxial germanium thin films

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Abstract: This study investigates ion irradiation effects on the direct band-gap recombination in Ge-based heterostructures. The findings provide a better understanding of the role of disorder in future Ge-based devices for quantum technology applications.

The study of the interaction between matter and high-energy ion irradiation has assumed a central role in the development of new technologies across various scientific fields. In the specific case of semiconductors, ion irradiation is no longer regarded exclusively as a source of structural degradation, but is now considered as an effective tool for modulating the electronic and optical properties of the materials, eventually as a viable path to yield controlled fabrication of quantum-light sources [1].

In this context, Germanium (Ge), a group IV semiconductor, is emerging as a key material for merging photonic and quantum electronics due to its advantageous optoelectronic properties and its compatibility with silicon-based technologies [2].

In this study, we utilize the direct band-gap recombination as an effective proxy to investigate the effect of ion irradiation on Ge-on-Si heterostructures. The study was extended to isotopically purified epitaxial layers to gather a better understanding of the role of lattice disorder on the overall optical properties.

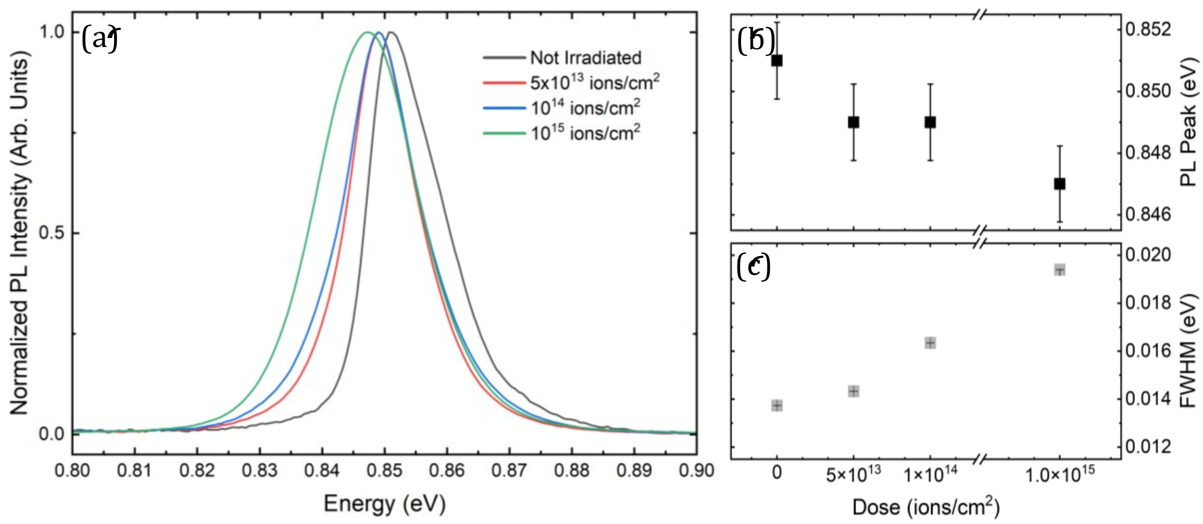

Fig. 1 Photoluminescence data of Ge-on-Si heterostructures irradiated with He^+ ions at 0.7 MeV with different doses. a) Ge direct band-gap recombination as a function of irradiation dose. b) Ge direct band-gap recombination peak position and c) FWHM as a function of the irradiation dose.

As shown in Fig. 1, photoluminescence measurements carried out at cryogenic temperatures demonstrated a progressive broadening, symmetrization and redshift of the direct-gap emission spectrum with increasing irradiation dose. All these behaviors can be rationalized in the framework of the formation of tail states within the gap. Similar, albeit less pronounced, results were obtained in isotopically-pure heterostructures, thus pointing towards the possible contribution associated to mass disorder.These findings offer important guidance for understanding and managing the effects of radiation in future Ge-based devices designed for space and quantum communication applications [3].

References

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